05 AGRICULTURE AND FORESTRY

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AGRICULTURE & FORESTRY

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Emissions and mitigation potential

Agriculture, forestry and other land use (AFOLU) is a broad category of emissions that has been used by the IPCC since 2006. It widely used in national greenhouse gas inventories and combines two previously distinct sectors: Land use, land use change and forestry (LULUCF), and Agriculture

The AFOLU sector accounts for about a quarter (about 10-12 billion tons of CO_2 eq./year) of the net GHG emissions.[1] The main sources of emissions from the AFOLU sector comprise deforestation, agricultural emissions from soil and nutrient management and livestock. It is worth noting that uncertainties in calculation of net AFOLU emissions is larger than for other sectors; however some of the broad figures mentioned in the recent IPCC 5th assessment report are shown in the figure below:

Graph 1: Total anthropogenic GHG emissions (GtCO2eq./yr) by economic sectors. Pull-out shows how indirect CO_2 emission shares (in % of total anthropogenic GHG emissions) from electricity and heat production are attributed to sectors of final energy use. Source: IPCC, 2014: Summary for Policymakers, In: Climate Change 2014, Mitigation of Climate Change.

Direct agricultural emissions

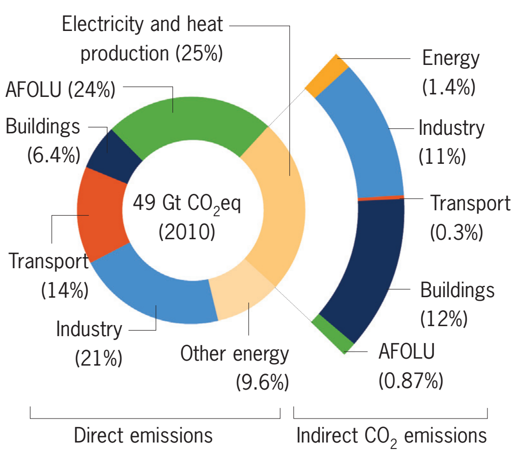
A wide range of agricultural activities emit GHGs and together they directly contributed about 11 per cent of total global anthropogenic emissions in 2010 (approximately 5 to 5.8 billion tons of CO_2 eq./year). Land-use and land-use change activities accounted for 9-11 per cent of total GHG emissions (4.3 to 5.5 billion tons of CO_2 eq./year).[2]

Emissions from energy use in agriculture added another 785 million tonnes of CO_2 eq. in 2010. The data includes emissions from fossil fuel energy needed to power machinery, irrigation pumps and fishing vessels.[3]

Most farm-related emissions come in the form of methane (CH_4) and nitrous oxide (N_2O). Enteric fermentation (belching and flatulence) from livestock and the addition of fertilisers and wastes to soils make up about 65 per cent of agriculture emissions globally.[4] Other sources include rice cultivation, burning of crop residues and manure management.

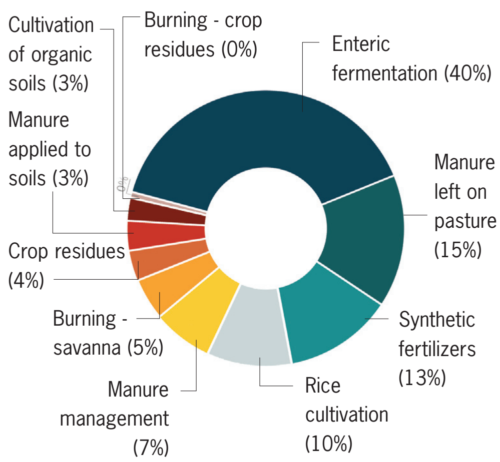
Graph 2: Emissions from enteric fermentation were the greatest contributor to agricultural emissions (40 per cent), followed by manure left on pasture (16 per cent), synthetic fertilizers (13 per cent), rice cultivation

Graph 1: Greenhouse gas emissions by economic sectors



Source: IPCC, 2014: Summary for Policymakers, In: Climate Change 2014, Mitigation of Climate Change.

Graph 2: Emissions from enteric fermentation



Source: FN Tubiello et al., FAO working paper series, March 2014

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Projected change in agricultural emissions in 2030 with respect to 2005

Type of emission	Total emissions 2005 ($MtCO_2e$) (million tonnes of CO_2 equivalent)	Total emissions 2030 (projection) ($MtCO_2e$)	% change
Agricultural soils (N_2O)	1,840	2,483	35
Enteric fermentation (CH_4)	1,894	2,320	22.5
Rice cultivation (CH_4)	501	510	1.8
Manure management (CH_4, N_2O)	398	466	17
Other emissions (CH_4, N_2O)	1,165	1,165	0
Total non-CO_2 emissions	5,798	6,944	20

(10 per cent), manure management (7 per cent) and burning of savanna (5 per cent)

Projections and trends for agriculture emissions

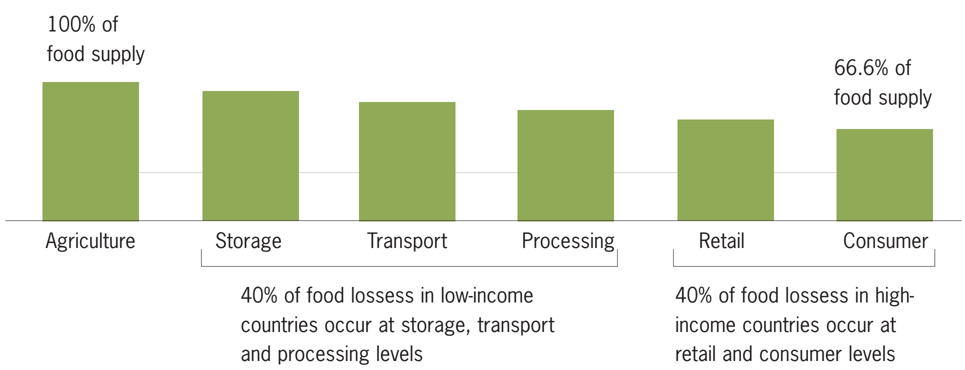
Total emissions from the agriculture sector (CH_4 and N_2O) are projected to increase by about 20 per cent by 2030. The largest increase will come from agricultural soils as can be seen in the table.[5]

Food supply chain emissions

Globally, roughly one-third of the food produced for human consumption, about 1.3 billion tonnes per year, is lost or wasted. Producing this much food accounts for 6-10 per cent of human-generated greenhouse gas emissions.[6]

- People in Europe and North America waste 95-115 kg of food each year, compared with only 6-11 kg a year for people in Sub-Saharan Africa and South Asia.[7]
- The average carbon footprint of food wastage is about 500 kg of carbon dioxide (CO_2) equivalents per person per year. Europe, North America, Oceania and industrial Asia have the highest per capita carbon footprint of food wastage (approximately 700-900 kg of CO_2 equivalent per person per year), while sub-Saharan Africa has the smallest footprint per person (about 180 kg of CO_2 equivalents)[8]
- Developing countries have high losses at the post-harvest and processing stages because of spoilage. Spoilage is high because of lack of modern transport and storage infrastructure, and financial, managerial and technical limitations in difficult climatic conditions.[9]
- The total amount of food wasted by consumers in industrialised countries is nearly as high as the total net food production in sub-Saharan Africa.[10]
- A total of 1.4 billion ha of land – 28 per cent of the world's agricultural area – is used annually to produce food that is lost or wasted. This is equivalent to the area of Canada and India put together, and dwarfed globally only by the size of Russia (1.7 billion ha).[11]
- Food wastage costs food producers some USD 750 billion annually.[12]
- High-income regions and Latin America are responsible for about 80 per cent of all meat waste.[13]

Graph 3: About a third of all food produced is lost in the food supply chain



Source: CGIAR Big Facts: http://ccafs.cgiar.org/bigfacts2014

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Emissions from livestock

- The livestock sector contributes an estimated 7,100 million tonnes of CO_2 equivalent per year, representing 14.5 per cent of human-induced greenhouse gas emissions.[14]
- Production of beef and cattle milk accounts for the majority of emissions, contributing 41 per cent and 20 per cent respectively of the sector's emissions. The production of pig meat and poultry meat and eggs contribute 9 per cent and 8 per cent respectively of the sector's emissions.[14]
- Feed production and processing, and enteric fermentation from ruminants are the two main sources of emissions, accounting for 45 per cent and 39 per cent respectively of sector emissions. Manure storage and processing account for 10 per cent of emissions.[14]
- The consumption of fossil fuel along livestock-sector supply chains accounts for about 20 per cent of sector emissions.[14]
- About 44 per cent of the sector's emissions are in the form of methane (CH_4). The rest is almost equally shared between N_2O (29 per cent) and CO_2 (27 per cent).[14]
- Global CH_4 emissions from enteric fermentation increased by 7 per cent from 1990 to 2005, from 1,763 million tonnes of CO_2 equivalent to 1,894 million tonnes, corresponding to 32.7 per cent of total agricultural emissions.[15]
- From 2005 to 2030, CH_4 emissions from enteric fermentation are projected to increase by 22 per cent, from 1,894 million tonnes of CO_2 equivalent to 2,320 million tones.[15]
- From 2005 to 2030, global CH_4 and N_2O emissions from manure management are projected to increase by 17 per cent, from 398 million tonnes of CO_2 equivalent to 466 million tonnes (US-EPA 2012 pp. 72-73).[15]

Equity in agriculture and livestock emissions

Agriculture has to be put at the heart of any poverty-reduction strategy. It is a multi-dimensional sector directly linked to the fight against hunger and malnutrition and to food security. At the same time, it is strongly influenced by international trade, finance, development cooperation and, increasingly, it is affected by climate change and environmental degradation. This diversity of functions and activities requires that issues relating to agriculture be treated in a holistic manner, and that the challenge of policy coherence be tackled both at national and international levels.[16]

India, China and a large number of African countries have countered by pointing out that emission-reduction efforts in the agricultural sector would affect farmers, who constitute a large percentage of the population and are often the poorest, in the developing world.[17] They also argue that the effort to reduce emissions should focus on fossil-fuel-based activities that spew out carbon dioxide – the greatest contributor to global warming by far. As paddy fields and livestock are some of the biggest causes of emissions, emission reduction in the sector has major implications for India and China.

Land-use change emissions and mitigation potential of forests

- Land-use change is a highly complex process. It results from the interaction of diverse drivers that may be direct or indirect and can involve numerous transitions, such as clearing, grazing, cultivation, abandonment and secondary regrowth.[20]
- Deforestation and land-use change accounts for 2,200-6,600 million tonnes of carbon dioxide (CO_2) equivalent per year, or 30-50 per cent of agricultural emissions and about 4-14 per cent of global emissions.[21]
- Land-use change to produce feed for livestock

Agriculture emissions – developed versus developing countries[18]

Developed countries, with 17 per cent of the world population, are responsible for 26 per cent of global N_2O emissions from soils, 30 per cent of methane CH_4 emissions from enteric fermentation, and 52 per cent of CH_4 and N_2O emissions from manure management. Agriculture emissions from developed countries increased by nearly 17 per cent between 1990 and 2005 due in good part to a massive increase in nitrogen fertiliser use in New Zealand and Australia and an increase of manure effluent of cattle, poultry and swine farms and manure application to soils in North America.

Despite roughly similar numbers of cattle per capita and many more small ruminants per capita in Africa than in developed countries, the latter's methane (CH_4) and nitrous oxide (N_2O) emissions from livestock manure are over 10 times greater than from African countries. Why? Because confined industrial animal agriculture stores manure in immense lagoons that produce significant quantities of these greenhouse gases.

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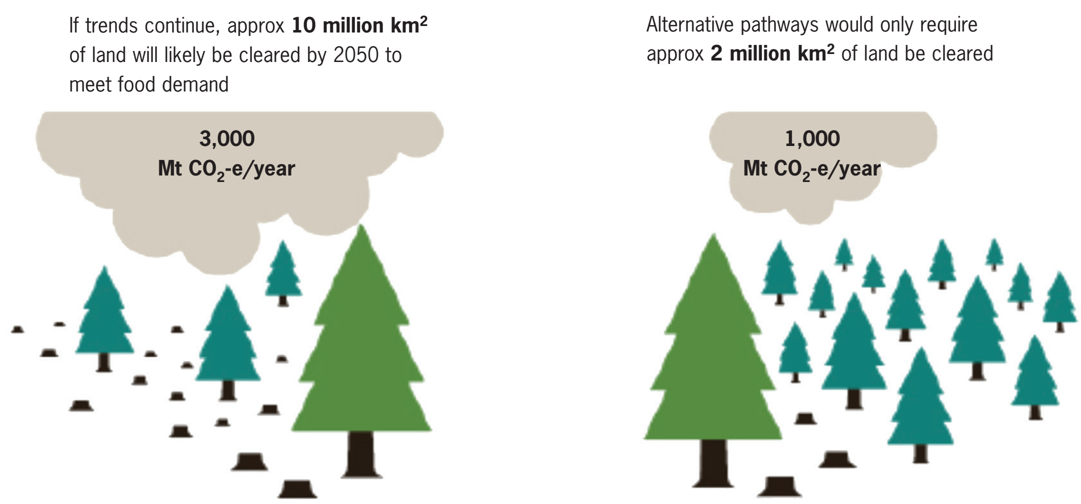
Illustrative comparison of developed and developing country agriculture emissions

Country	Non-CO_2 GHG emissions from agriculture in 2010 (Mt CO_2 eq)	Per capita non-CO_2 emissions agriculture (tonnes CO_2 eq)	Per capita N_2O emissions from agricultural soils (tonnes CO_2 eq)	Per capita emissions from livestock (from (tonnes CO_2 eq)	Per capita meat consumption (kg)
France	102.7	1.63	0.86	0.77	88.6
Ghana	8.7	0.36	0.07	0.08	9.9
India	732.3	0.60	0.18	0.18	5.2
Malawi	12.8	0.86	0.66	0.09	5.1
New Zealand	37.1	8.49	2.91	5.59	142.1
United States	454.9	1.46	0.78	0.64	124.8

Source: Climate-Justice 2012[19]

Agriculture is responsible for 75 per cent of global deforestation



Source: CGIAR Big Facts: http://ccafs.cgiar.org/bigfacts2014/#

accounts for about 9 per cent of livestock-sector emissions.[22]

- Since 1850, land-use change has directly contributed some 35 per cent of human-generated CO_2 emissions.[23]
- Past trends imply that about 10 million square km of land will be cleared by 2050 to meet food demand, leading to annual emissions of 3,000 million tonnes of CO_2 equivalent. Reducing land clearing to about 2 million square km would reduce greenhouse gas emissions to 1,000 million tonnes of CO_2 equivalent per year.[24]

Co-benefits of mitigation in agriculture

Temperature rise above 2ºC will produce increasingly unpredictable and dangerous impacts for people and ecosystems, but particularly for agricultural systems. Impacts on the agricultural sector that are already occurring but expected to intensify include increased irrigation water needs, increased spread of animal and crop diseases and pests, reduced forage quality, and reduced crop and pasture yields. These impacts stem from changes in surface temperatures, timing of seasons and frequency and severity of severe weather events, such as droughts, floods, and heatwaves.[25]

AFOLU plays a central role for food security and sustainable development. The most cost-effective mitigation options in forestry are afforestation, sustainable forest management and reducing deforestation, with large differences in their relative importance across regions. In agriculture, the most cost-effective mitigation options are cropland management, grazing land management, and restoration of organic soils.

The main mitigation options within AFOLU, as listed in the IPCC 5th Assessment Report chapter 11 on Agriculture, involve one or more of these strategies:

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- reduction/prevention of emissions to the atmosphere by conserving existing carbon pools in soils or vegetation that would otherwise be lost or by reducing emissions of CH_4 and N_2O
- sequestration – enhancing the uptake of carbon in terrestrial reservoirs, and thereby removing CO_2 from the atmosphere
- reducing CO_2 emissions by substitution of biological products for fossil fuels or energy intensive products
- Demand side options (e.g. by lifestyle changes, reducing losses and wastes of food, changes in human diet, changes in wood consumption), though known to be difficult to implement, may also play a role.

The IPCC 5th Assessment Report also estimates the potentials for reducing greenhouse gases in agriculture as follows:

- Global economic mitigation potentials in agriculture in 2030 are estimated to be 0.5-10.6 GtCO2eq/yr
- Reducing food losses and waste can reduce GHG emissions by 0.6-6.0 GtCO2eq/yr
- Changes in diet could result in GHG emission savings of 0.7-7.3 GtCO2eq/yr
- Forestry mitigation options are estimated to contribute 0.2-13.8 GtCO2/yr

Note: The points under Food Supply, Livestock and Forestry emissions were adapted from the CGIAR Big facts an open-access resource. http://ccafs.cgiar.org/bigfacts2014/#about=true

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